Designation: D 4716 – 00

Test Method for
Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head[1]

1. Scope

1.1 This test method covers the procedure for determining the flow rate per unit width within the manufactured plane of geosynthetics under varying normal compressive stresses and a constant head. The test is intended primarily as an index test but can be used also as a performance test when the hydraulic gradients and specimen contact surfaces are selected by the user to model anticipated field conditions.

1.2 This test method is limited to geosynthetics that allow continuous in-plane flow paths to occur parallel to the intended direction of flow.

1.3 The values stated in SI units are to be regarded as the standard. The values stated in parentheses are provided for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 4354 Practice for Sampling of Geosynthetics for Testing[2]

D 4439 Terminology for Geotextiles[2]

D 4491 Test Methods for Water Permeability of Geotextiles by Permittivity[2]

3. Terminology

3.1 *Definitions:*

3.1.1 *geocomposite*, *n*—a product fabricated from any combination of geosynthetics with geotechnical materials or other synthetics which is used in a geotechnical application. **(D 4439)**

3.1.2 *geonet*, *n*—a geosynthetic consisting of integrally connected parallel sets of ribs overlying similar sets at various angles for planar drainage of liquids or gases. **(D 4439)**

3.1.3 *geosynthetic*, *n*—a planar product manufactured from polymeric material used with soil, rock, earth, or other geotechnical engineering related material as an integral part of a man-made project, structure, or system. **(D 4439)**

3.1.4 *geotechnics*, *n*—the application of scientific methods and engineering principals to the acquisition, interpretation, and use of knowledge of material of the earth's crust to the solution of engineering problems.

3.1.4.1 *Discussion*—Geotechnics embraces the fields of soil mechanics, rock mechanics, and many of the engineering aspects of geology, geophysics, hydrology, and related sciences. **(D 4439)**

3.1.5 *geotextile*, *n*—a permeable geosynthetic comprised solely of textiles. **(D 4439)**

3.1.6 *gravity flow*, *n*—flow in a direction parallel to the plane of a geosynthetic driven predominantly by a difference in elevation between the inlet and outflow points of a specimen.

3.1.6.1 *Discussion*—The pressure at the outflow is considered to be atmospheric. **(D 4439)**

3.1.7 *head (static)*, *n*—the height above a standard datum of the surface of a column of water (or other liquid) that can be supported by a static pressure at a given point. The static head is the sum of the elevation head and the pressure head. **(D 5092)**

3.1.8 *hydraulic gradient*, *i*, *n*—the loss of hydraulic head per unit distance of flow, dh/dL. **(D 4439)**

3.1.9 *hydraulic transmissivity*, θ ($L^2 T^{-1}$), *n*—for a geosynthetic, the volumetric flow rate per unit width of specimen per unit gradient in a direction parallel to the plane of the specimen.

3.1.9.1 *Discussion*—"transmissivity" is technically applicable only to saturated, laminar hydraulic flow conditions (see Appendix X1). **(D 4439)**

3.1.10 *in-plane flow*, *n*—fluid flow confined to a direction parallel to the plane of a geosynthetic. **(D 4439)**

3.1.11 *index test*, *n*—a test procedure that may contain known bias but which may be used to establish an order for a set of specimens with respect to the property of interest. **(D 4439)**

3.1.12 *laminar flow*, *n*—flow in which the head loss is proportional to the first power of the velocity. **(D 4439)**

3.1.13 *normal stress* (FL^{-2}), *n*—the component of applied

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[1] This test method is under the jurisdiction of ASTM Committee D-35 on Geosynthetics and is the direct responsibility of Subcommittee D35.03 on Hydraulic Properties.

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[2] *Annual Book of ASTM Standards*, Vol 04.09.

stress that is perpendicular to the surface on which the force acts. **(D 4439)**

3.1.14 *performance test, n*—a test that simulates in the laboratory as closely as practical selected conditions experienced in the field and which can be used in design. **(D 4439)**

3.1.15 *pressure flow, n*—flow in a direction parallel to the plane of a geosynthetic driven predominantly by a differential fluid pressure. **(D 4439)**

3.1.16 *turbulent flow, n*—that type of flow in which any water particle may move in any direction with respect to any other particle, and in which the head loss is approximately proportional to the second power of the velocity. **(D 4439)**

3.1.17 For definitions of terms relating to geosynthetics, refer to Terminology D 4439.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *steady flow, n*—flow conditions that do not vary with time.

3.2.2 *uniform flow, n*—conditions where the flow area and the mean velocity in the direction of flow are constant.

4. Summary of Test Method

4.1 The flow rate per unit width is determined by measuring the quantity of water that passes through a test specimen in a specific time interval under a specific normal stress and a specific hydraulic gradient. The hydraulic gradient(s) and specimen contact surfaces are selected by the user either as an index test or as a performance test to model a given set of field parameters as closely as possible. Measurements may be repeated under increasing normal stresses selected by the user.

4.1.1 Hydraulic transmissivity should be determined only for tests or for specific regions of tests that exhibit a linear flow rate per unit width versus gradient relationship, that is, laminar flow (see Appendix X1).

5. Significance and Use

5.1 This test method is intended either as an index test or as a performance test used to determine and compare the flow rate per unit width of one or several candidate geosynthetics under specific conditions.

5.2 This test method may be used as an index test for acceptance testing of commercial shipments of geosynthetics but caution is advised since information on between-laboratory precision of this test method is incomplete. Comparative tests as directed in 5.2.1 may be advisable.

5.2.1 In case of a dispute arising from differences in reported test results when using this test method for acceptance testing of commercial shipments, the purchaser and the supplier should first confirm that the tests were conducted using comparable test parameters including specimen conditioning, normal stress, seating period, hydraulic gradient, test water temperature, etc., then conduct comparative tests to determine if there is a statistical bias between their laboratories. Competent statistical assistance is recommended for the investigation of bias. As a minimum, the two parties should take a group of test specimens that are as homogenous as possible and that are formed from a lot of the material of the type in question. The test specimens should then be randomly assigned in equal numbers to each laboratory for testing. The average results from the two laboratories should be compared using the Student's *t*-test for unpaired data and an acceptable probability level chosen by the two parties before the testing is begun. If bias is found, either its cause must be found and corrected or the purchaser and supplier must agree to interpret future test results in light of the known bias.

6. Apparatus

6.1 A schematic drawing of an assembly is shown in Fig. 1. The individual components and accessories are as follows:

6.1.1 *Base*—A sturdy metal base with smooth flat bottom and sides capable of holding a test specimen of sufficient area and thickness. All seams between the bottom surface and sides of the base must be water tight and not inhibit in-plane flow of water through the specimen. For geotextile testing, all surfaces of the base in contact with the specimen shall be covered by a thin layer of rubber material of low compressibility in order to ensure a tight seal.

6.1.2 *Reservoir*—A plastic, glass or metal water reservoir extending the full width of the base. The height of the reservoir shall be at least equal to the total length of the specimen. The reservoir shall have provision for maintaining a constant water level at any of several elevations.

6.1.3 *Loading Mechanism*—Capable of sustaining a constant normal compressive stress on the specimen ranging from 10 kPa (1.45 psi) to at least 500 kPa (70 psi) on a 300- by 300-mm (12- by 12-in.) loaded area with an accuracy of ±1 %. The use of static weights, pneumatic bellows systems, or piston applied stresses meeting the above conditions may be considered sufficient for use in this test.

6.1.4 *Outflow Weir*—A plastic, glass or metal reservoir extending the full width of the base at the outlet side of the specimen having, at the opposite side, a rectangular weir at an elevation higher than the elevation of the upper surface of the specimen.

6.1.5 *Discussion*—The weir is used to sustain the steady, constant head condition on the outflow side of the specimen. For small discharge conditions, a narrow rectangular or triangular, V-notch weir may be warranted.

6.1.6 *Outflow Collection*—A catch trough extending the entire width of the base is used for collection and measurement of the outflow from the specimen.

6.1.7 *Rubber Substrate/Superstrate*—(optional) Rubber sheets cut to fit the base may be used to model soil adjacent to the geosynthetic on one or both sides of the specimen if desired. The compressibility and thickness of the rubber layer should be selected such that it adequately represents the soil

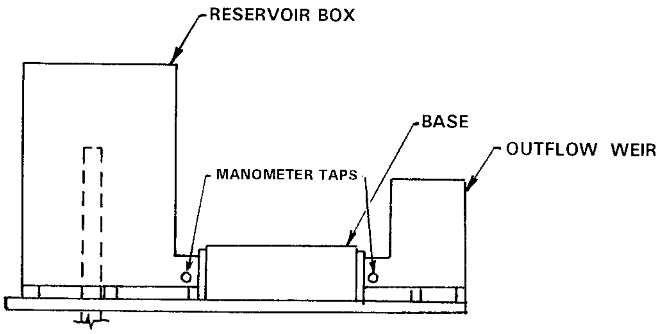

FIG. 1 A Constant Head (In-Plane) Flow Rate Testing Device

being modeled. The material selected should not allow continuous flow channels to exist through or around the rubber layer. These layers shall extend the entire length and width of the base. The thickness of the rubber layers shall be at least twice the thickness of the geosynthetic specimen to be tested.

6.1.7.1 Compare the uncompressed thickness measured prior to use with the thickness measured at least one hour after use. If the thickness decreases by 20 % or more, or if permanent indentations or damage are evident in the sheet, discard the sheet and retest using a new sheet.

6.1.8 *Thickness Monitoring Device*—(optional) In the form of a dial gauge and the like may be used to monitor the change in the thickness of the geosynthetic specimen in the testing device under various applied normal stresses.

6.1.9 *Manometers*—Open manometers are located at the inlet and outlet ends of the specimen in the reservoir box and outflow weir respectively (see Fig. 1). The manometer taps are placed at the same level as the base of the specimen as close to the specimen ends as practical. Extend the manometers with clear tubing to a height at least as high as the maximum water level in the reservoir box.

6.2 In addition, the apparatus must not be the controlling agent for flow during the test. It will be necessary to establish calibration curves of volumetric flow rate versus gradient for the apparatus alone using rigid, open channel substitutes (calibration blocks) representing the range of geosynthetic thicknesses to be tested in order to establish compliance with this requirement. (See Annex A1.)

7. Sampling

7.1 *Lot Sample*—Divide the product into lots and for a lot to be tested take the lot sample as directed in Practice D 4354.

7.2 *Laboratory Sample*—Consider the units in the lot sample as the units in the laboratory sample. For the laboratory sample, take a full width swatch of sufficient length along the roll edge so that the requirements of 7.3-7.5.3 can be met.

7.3 *Test Specimens—Geotextiles*—For acceptance testing, remove three specimens from each laboratory sample which are spaced along a diagonal extending across the swatch. Cut the specimens such that the longer dimension is parallel to the geotextile direction (for example, machine or cross-machine direction) to be tested. For performance testing, the number of specimens to be tested is selected by the user.

7.3.1 Make the geotextile specimen width 300 mm (12 in.) and the specimen length at least 350 mm (14 in.), or the length to allow the specimen to extend into the reservoir and weir a distance of 25 mm (1 in.), whichever is greater.

7.4 *Test Specimens—Geonets*—For acceptance testing, remove two specimens from each unit in the laboratory sample with the longer dimension parallel to the geonet direction (for example, machine or cross-machine direction) to be tested. For performance testing, the number of specimens is selected by the user.

7.4.1 Make the geonet specimen width 300 mm (12 in.). Make the specimen length at least 350 mm (14 in.), or the length to allow the specimen to extend into the reservoir and weir a distance of 25 mm (1 in.), whichever is greater.

7.5 *Test Specimens—Geocomposites*— For acceptance testing, remove two specimens from each unit in the laboratory sample. Obtain the specimens with the longer dimension parallel to the geocomposite direction (for example, machine or cross-machine direction) to be tested. For performance testing, the number of specimens is selected by the user.

7.5.1 For geocomposites manufactured with the full product width less than 300 mm (12 in.), the specimen width is equal to the manufactured product width. The specimen length is at least 350 mm (14 in.), or the length to allow the specimen to extend into the reservoir and weir a distance of 25 mm (1 in.), whichever is greater.

NOTE 1—The actual length of the geocomposite specimen may have an influence on the measured head losses and associated gradients; therefore, the specimen length of 350 mm (14 in.) will be considered standard. In any case, always report the actual specimen length used.

7.5.2 For geocomposites manufactured with a full product width 300 mm (12 in.) or greater, the specimen width is 300 mm (12 in.) unless the product cannot be cut to width without altering the product structure.

7.5.3 For geocomposites consisting of two or more different geosynthetic components, determine the specimen dimensions for each individual material in accordance with the applicable section, 7.3, 7.4 or 7.5.2. The minimum dimension of the specimens shall then be dictated by the component requiring the largest minimum size. This requirement does not apply for components sized per 7.5.1 which have manufactured widths less than 300 mm (12 in.).

8. Test Parameter Selection

8.1 *Selection of Substrate and Superstrate*:

8.1.1 *Index Testing*—For acceptance testing, the contact surfaces should be prescribed by the material specification. In the absence of a specification, use rigid sub and superstrates to minimize the variables impacting the test results.

8.1.2 For performance testing, the nature of the material in contact with the geosynthetic in the field should be modeled. A rigid platen on one or both sides of the specimen simulates similarly rigid surfaces (such as concrete walls or stiff geomembranes) where intrusion into the geosynthetic openings or pore spaces is not anticipated. Where intrusion is expected (as is the case for a geotextile in contact with soil or a geonet/geotextile/soil section) a layer of rubber membrane or representative soil may be placed between the platen and the geosynthetic specimen.

NOTE 2—Tests performed using site-specific soils are recommended when the end use of the material is known. The long term effect of soil clogging should be considered when performing tests described in this test method.

8.2 *Gradient Selection*:

8.2.1 *Index Testing*—For acceptance testing, the test gradients should be prescribed by the material specification. In the absence of a specification, use three gradients selected from the following values; 0.05, 0.10, 0.25, 0.50 and 1.0.

8.2.2 *Performance Testing*—Select a test hydraulic gradient that is appropriate for the end use of the material and for specific field conditions. When specific field conditions are not known, use one of the following recommended gradients as well as at least two lesser gradients.

8.2.2.1 A maximum hydraulic gradient of 1.0 is suggested for tests intended to model gravity flow conditions.

8.2.2.2 A maximum hydraulic gradient of 0.1 is suggested for tests intended to model pressure flow conditions.

8.3 *Selection of the Applied Normal Compressive Stresses*:

8.3.1 *Index Testing*—For acceptance testing, the applied normal compressive stress(es) should be prescribed by the material specification. In the absence of a user or supplier specification, perform flow rate testing using a minimum of three applied normal stresses selected from the following values; 10, 25, 50, 100, 250 and 500 kPa (1.45, 3.63, 7.26, 14.51, 36.28 and 72.55 psi).

8.3.2 For performance testing, select the minimum and maximum normal stress to be applied as to model the specific field conditions. Perform the tests using a minimum of three applied normal stresses, selecting at least one value greater and one value less than the known design stress value.

8.3.2.1 Where the design or maximum normal compressive stress for a particular application is known, it may be sufficient to test the specimen under a single stress. This option should only be used when selected by the user or product specifier.

9. Procedure

9.1 Place the specimen substratum, if any, on the test device base.

9.2 Trim the test specimen to the dimensions prescribed in 7.3-7.5, and then place the test specimen over the substratum ensuring that all wrinkles, folds, etc. are removed.

9.2.1 Seal the sides of the specimen parallel to the direction of flow by wrapping the test specimen in a thin sheet of low compressibility plastic or rubber membrane, using a cast-in-place rubber or wax edge seal, or other measure (to prevent side leakage). This precaution may not be warranted for test specimens that are rectangular in profile, placed between rigid surfaces and cut to fit snugly against the sides of the base.

NOTE 3—The elimination of leakage paths along the sides of the test specimen and along the loading tray adjacent to the upper surface of the specime merits close attention when testing geotextile materials. The user is cautioned of the relatively high variability (see 12.1) in the test results, that may be directly related to the laboratory's ability to address these fugative flows.

9.3 Place the desired superstratum, if any, over the test specimen in a similar manner.

9.4 Seat the top plate (platen) on the test assembly applying a small seating stress of 5 to 10 kPa (0.73 to 1.45 psi) and slowly fill the reservoir with water allowing water to flow through the test specimen. From this point forward, the specimen must be kept saturated at all times.

9.4.1 The test water should be maintained at 21 ± 2°C (70 ± 4°F) throughout the test duration.

9.4.2 Visually check for preferential flow paths along the boundaries of the test specimen. If such flows are observed, re-seat or replace the test specimen as required.

NOTE 4—The use of deaired water is recommended for testing geotextiles and may be a consideration for test sections that include geotextiles where dissolved oxygen may influence the test results. Refer to Test Methods D 4491 for details regarding deaired water.

9.5 Seat the specimen under the minimum normal compressive stress for a minimum period of 15 min.

9.5.1 The minimum seating period suggested may not be sufficient for acceptance testing of geosynthetics that exhibit time dependent structural instability or other compressive response that significantly impacts the flow rate for stresses sustained longer than 15 min. The seating period selected should be based on long-term compression testing data at comparable stress levels.

9.5.2 For performance testing, seating periods may have to be extended for a considerable length of time in order to determine the minimum or "long term" flow rate per unit width. This is especially true for geosynthetics and sections including soils that exhibit compression creep or other long term deformation.

9.6 After the seating period has elapsed, fill the reservoir to the level corresponding to the hydraulic gradient selected for the test.

9.6.1 Determine the system hydraulic gradient by computing the difference in water elevations between the reservoir and weir manometers and dividing this value by the length of the specimen subjected to the normal compressive stress. For most specimens this length will be 300 mm (12 in.). Adjust the elevation of the water level in the reservoir box to change the system gradient.

9.7 Once steady flow through the specimen is observed, allow at least 0.0005 m^3 of water to flow through the specimen. Record the time required for at least an additional 0.0005 m^3 of water to pass through the specimen. If this time exceeds 15 min, record the quantity of flow collected at 15 min for use in calculations of the flow rate per unit width or hydraulic transmissivity, or both. Repeat the flow reading at least three times for each hydraulic gradient selected.

9.8 Increase the normal compressive stress and repeat the procedure outlined in 9.5-9.7 until the maximum desired stress is reached.

9.9 Compare flow rate data for each test to the flow rate data plotted on the appropriate calibration block curve for the device. For a given flow rate, if the hydraulic gradient value for the calibration block is more than 5 % of the corresponding gradient for the geosynthetic, then the test data is invalid and the device cannot be used to evaluate the test condition modeled.

10. Calculation

10.1 Calculate the flow rate per unit width, q_w, as follows:

$$q_w = Q_t / W$$

where:

q_w = flow rate per unit width, m^3/s-m (gpm/ft),
Q_t = measured average quantity of fluid discharged per unit time, m^3/s (gpm), and
W = width of the specimen, m (ft).

10.1.1 Results can be expressed as a plot of flow rate per unit width versus hydraulic gradient (see Fig. 2) or versus normal compressive stress (see Fig. 3).

10.2 Calculate the hydraulic transmissivity, θ, as follows (Note X2.1):

$$\theta = (Q_t L)/WH$$

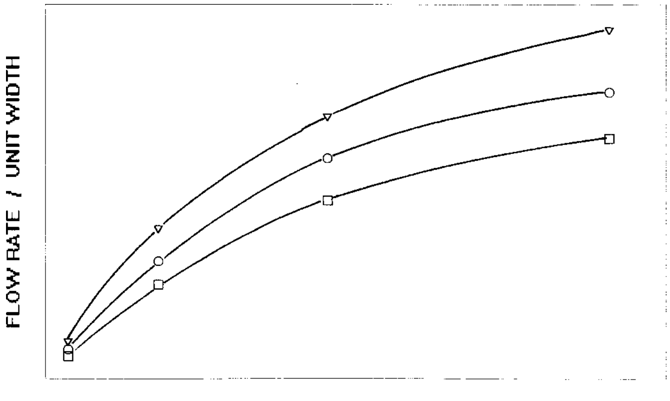

FIG. 2 Typical Plot of Flow Rate per Unit Width Versus Hydraulic Gradient Under Several Normal Compressive Stresses

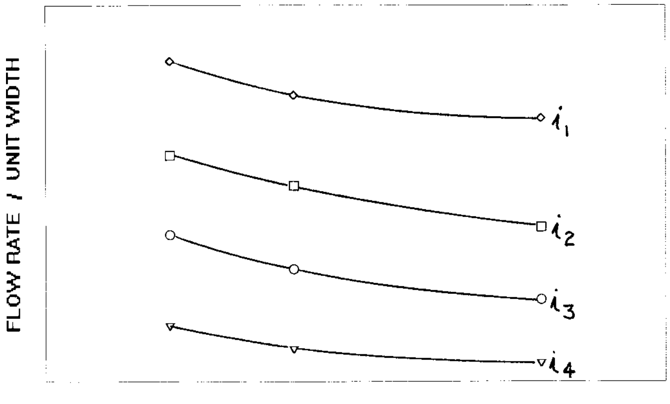

FIG. 3 Typical Plot of Flow Rate per Unit Width Versus Normal Compressive Stress at Several Hydraulic Gradients

where:

θ = hydraulic transmissivity, m^2/s,
Q_t = measured average quantity of fluid discharged per unit time, m^3/s,
L = length of specimen subjected to the normal compressive stress. Do not consider the length of the specimen that extends into the reservoir or weir,
W = width of the specimen, m, and
H = difference in total head across the specimen, m.

NOTE 5—The calculation of the hydraulic transmissivity is applicable only for tests or specific regions of tests conducted under laminar flow conditions. To determine the flow regime, plot the flow rate per unit width versus the hydraulic gradient for each normal compressive stress (see 10.1 and Fig. 2). The data points for a given normal compressive stress form a straight line intersecting the origin if the test, or a region of the test, was conducted under laminar flow conditions. The hydraulic transmissivity is equal to the slope of the straight line region on these plots (see Appendix X1).

10.2.1 Results can be presented as a plot of hydraulic transmissivity versus normal compressive stress (see Fig. 4).

11. Report

11.1 The report on the flow rate per unit width or hydraulic transmissivity test, or both, shall include the following information:

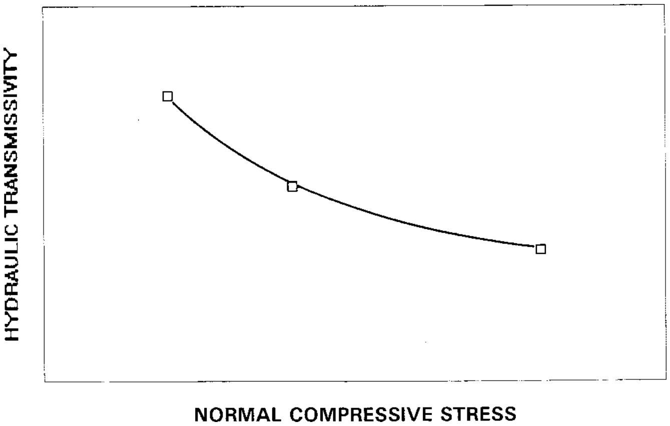

FIG. 4 Typical Plot of Hydraulic Transmissivity Versus Normal Compressive Stress

11.1.1 Project, type of geosynthetic(s) tested and included in sub and super stratum if applicable, method(s) of sampling, and directions tested.

11.1.2 Type of test performed and field conditions modeled (for example, contact sub and super stratum compositions and the like).

11.1.3 Calibration curve(s) for the test device with the appropriate calibration block thickness(es), or a statement that a device calibration was conducted and that the equipment hydraulic losses are less than 5 % of the losses measured in the tests.

11.1.4 A statement of any departures from suggested testing procedure so the results can be evaluated and used.

11.1.5 Complete test data, including hydraulic head, quantity of flow collected, seating period for each stress, thickness (if monitored), temperature of test water, and specimen length and width.

11.1.6 Test plots expressing flow rate per unit width versus hydraulic gradient for each normal compressive stress or versus normal compressive stress for each hydraulic gradient and, when applicable, hydraulic transmissivity versus normal compressive stress.

11.1.7 If a rubber substrate was used as a superstrate or substrate, or both, report the thickness, type of rubber and durometer hardness as well as the comparative test data generated for supporting the rubber selected.

11.1.8 Long term creep/compression data for the geosynthetic, subject to comparable stress levels, which extend over a time interval that will provide insight into the long term in-plane flow rate behavior relative to the seating period used and the long term compressive creep behavior of the geosynthetic.

11.1.8.1 When used as an index test for acceptance of commercial shipments of qualified products, long term creep/compression data is not required.

12. Precision and Bias

12.1 *Precision*:

12.1.1 *Interlaboratory Test Program*—An interlaboratory study of this test method was run in 1997 through 1998. The design of the experiment, similar to that of Practice E 691, and a within-between analysis of the data, are given in an ASTM

Research Report[3] . Program details are provided in Table 1. The "geonet" was an HDPE geonet approximately 6-mm thick. The "composite" consisted of the same geonet with an 270 g/m^2 (8-oz/sy) nonwoven polyester geotextile bonded to each side. The "geotextile" was a 540 g/m^2 (16-oz/sy) nonwoven polyester. The "edge drain" was a core-type tested without the geotextile wrap.

TABLE 1

Material	No. Specimens Per Sample Set	No. Laboratories	Normal Load, kPa	Gradient	Seating Period
Geonet	2	8	250	1.0	15 min
Composite	2	8	250	1.0	15 min
Geotextile	3	8 (7)	250	1.0	15 min
Edge Drain	2	5	250	0.05	15 min

12.1.2 *Test Result*—The precision information is given in Table 2 for the four materials. The test results are in units of l/s·m (gpm/ft).

12.1.3 *Precision*—

12.2 *Bias*—The procedure in this test method for measuring the hydraulic transmissivity and flow rate per unit width of geosynthetics has no bias because the values of hydraulic transmissivity and flow rate per unit width can be defined only in terms of a test method.

13. Keywords

13.1 geosynthetics; hydraulic transmissivity; in-plane flow; index test; performance test

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[3] Supporting data have been filed at ASTM Headquarters. Request RR:D35-1008.

TABLE 2

Material	Average l/s·m (gpm/ft)	Repeatability Limit, CVSr, %	Reproducibility Limit, CVSR, %	95 % Confidence Repeatability Limit, CVr, %	95 % Confidence Reproducibility Limit, CVR, %
Geonet	2.18 (10.5)	7.0 %	7.3 %	19.8 %	20.5 %
Composite	0.212 (1.02)	10.6 %	21.2 %	29.8 %	59.5 %
Geotextile	.0108 (.052)	53.4 %	93.3 %	150 %	261 %
Edge drain	3.55 (17.1)	3.9 %	8.0 %	10.9 %	22.3 %

ANNEX

(Mandatory Information)

A1. TRANSMISSIVITY/FLOW RATE DEVICE CALIBRATION

A1.1 Calibration is conducted using an open channel (calibration block) or a similar object which allows flow to pass through the flow rate device unimpeded. Assemble the device with the calibration block in place of the geosynthetic specimen. The inside height of the calibration block opening shall be equal to or greater than the uncompressed thickness of the geosynthetic specimen (excluding adjacent soil or other components that are not intended to convey flow).

A1.2 Construct calibration blocks from rigid material such as steel, aluminum or acrylic. The blocks are fabricated to provide an open channel for flow with a minimum of flow disruption across the width of the base. The upstream and downstream ends of the blocks are open. The blocks should fit tightly within the loading device specimen area. Fabricate a series of calibration blocks to simulate the thicknesses of the various geosynthetics to be tested in the device.

A1.3 Assemble the transmissivity device and conduct testing as outlined in the procedure section using the calibration block. Apply a nominal seating load (10 kPa is suggested) on the calibration block during testing. Conduct the calibration using at least five flow rates ranging from the rate corresponding to the lowest measurable gradient (that is, head loss between the reservoir and weir) to a flow rate in excess of the maximum expected while testing geosynthetics of the block thickness used.

A1.4 No minimum seating period is required. At each flow rate, compute the hydraulic gradient values based on the head loss between the reservoir and weir manometers and a flow length equal to the calibration block length.

A1.5 Plot the measured flow rates versus the computed block gradients multiplied by 20. This curve is the calibration curve for the calibration block used Fig. A1.1 .

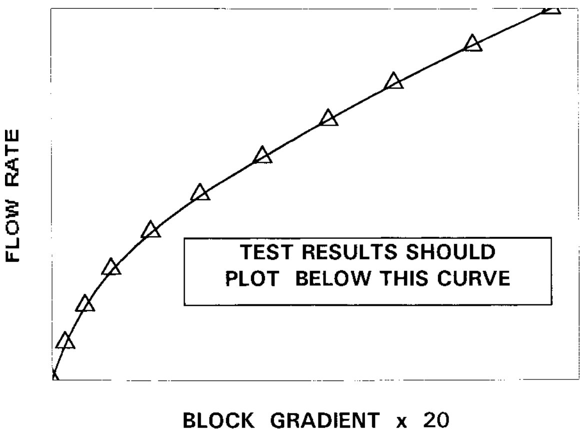

FIG. A1.1 A Typical Calibration Curve

APPENDIXES

(Nonmandatory Information)

X1. GRAPHIC DEFINITION: HYDRAULIC TRANSMISSIVITY

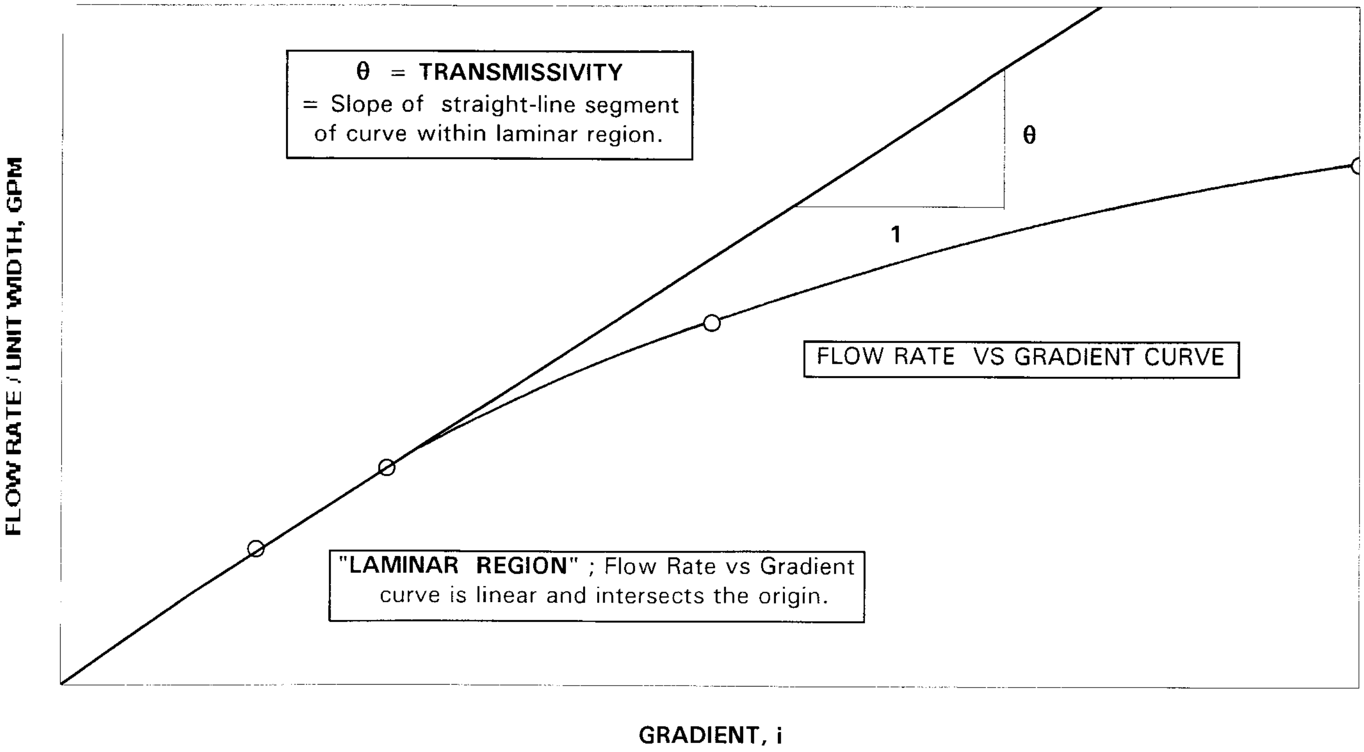

FIG. X1.1 Hydraulic Transmissivity

X2. DISCUSSION REGARDING THE SELECTION OF SUITABLE SEATING CONDITIONS

X2.1 This appendix has been prepared to address the selection of the seating period for testing certain types of geosynthetics (see Note X2.1), which may be characterized by significant[4] time-dependent compression strains under constant loading. While all geosynthetic materials currently in use for drainage applications exhibit "creep" deformations under constant loading, the subject products can experience large deformations or collapse at some time after the initial application of a constant sustained load.

X2.2 Fig. X2.1 show examples of the compression strain versus time behavior for a "nontime-dependent" (geonet) and a "time dependent" (a core-type composite) material subject to three different compressive stress levels. Note the "spikes" in the deformation versus time curves where the core-type composite collapsed at some time after initial load application. This figure illustrates the unique compressive characteristic of materials addressed by this appendix, that is, materials, which are subject to large compressive deformation at some time after initial application of a constant load.

X2.3 This time dependent compression behavior merits consideration in conjunction with the use of this test method for the selection of the seating conditions, that is, compressive stress and seating period, which would produce compressive strain levels in a short term test that are comparable to those expected under actual service conditions.

X2.3.1 For example, for a specific core-type composite, the estimated normal comporessive load of 96 kPa (2000 psf)

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[4] Significant in terms of the measured flow rate per unit width.

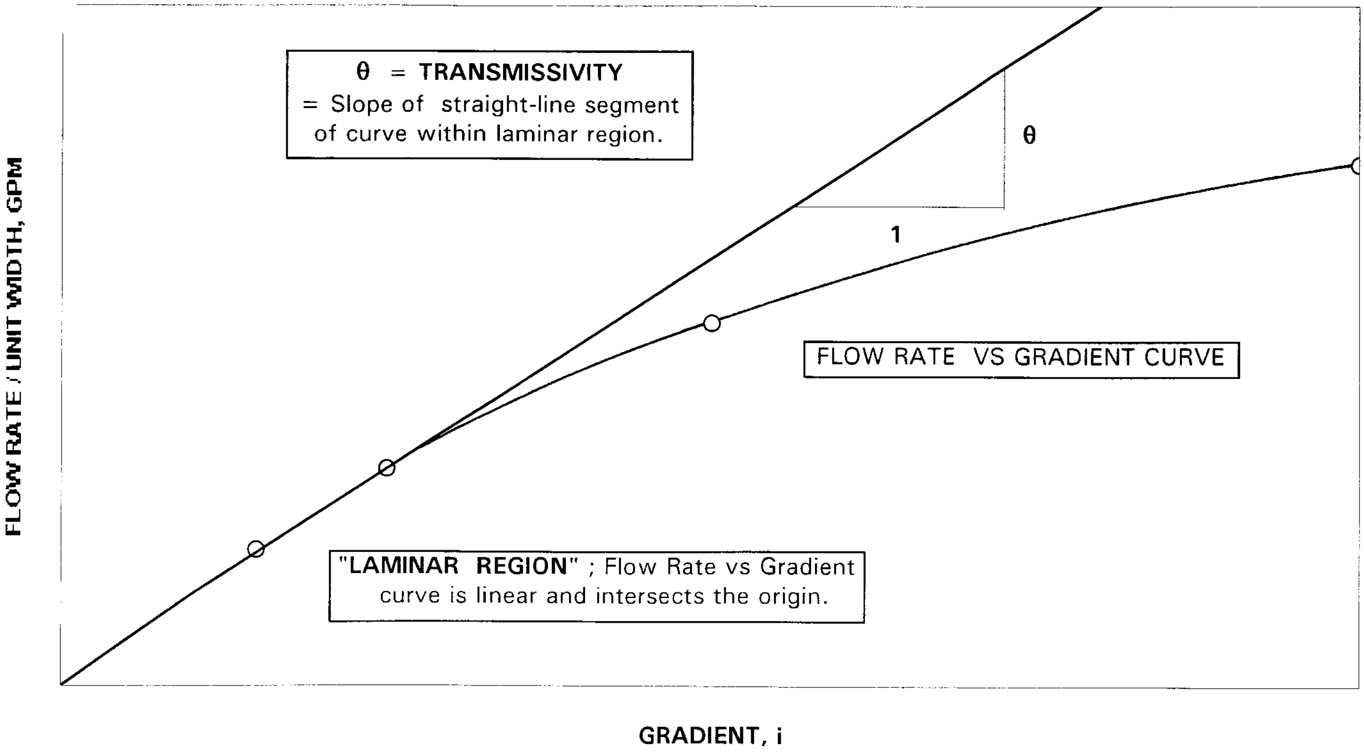

FIG. X2.1 Strain Versus Time Curves for a Specific Core-Type Geocomposite

results in a compressive deformation approaching 10 % after 10 000 h; a compressive stress of 167 kPa (3500 psf) produces 10 % deformation after a seating period of 1 h. Based on this information, flow rate tests performed using a compressive stress of 167 kPa (3500 psf) and a seating period of 1 h may be suitable for product compliance, that is, commercial acceptance testing, and would be expeditious from a testing standpoint. Note that, for this example, if the 167 kPa (3500 psf) loading is sustained for an additional 10 h, the composite would collapse. The normal compressive loading may or may not be representative of actual field loading conditions.

NOTE X2.1—This appendix addresses the selection of a suitable seating period for any geosynthetic exhibiting time-dependent compressive behavior described herein. These may include products other than those which are currently in use.

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